“Post-mortem Iris Recognition with Deep Learning Based Image Segmentation”

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Abstract

Recognition and identification of one's own person has become a difficult chore for us in the most complicated circumstance that exists today. When it comes to biometric recognition or confidentiality, the latest prominent advancement within the area of digital innovations has been a shift forward into a biometric-based coded human identification architecture. ATM transactions, passport verification, secure access to offices or buildings, online fund transfers, and e-government services, to name a few examples, are all legitimate applications in which every person is required to prove his or her own identification on a routine basis. In such situations, maintaining and protecting an individual's identity and information security has proven to be very difficult to manage and maintain. The iris recognition technology is being utilised successfully in situations where security is of the utmost importance. Because of its distinct characteristics, iris identification has been discovered to be quite successful in the authentication process. For more than 25 years, iris recognition has provided the society with a safe and quick method of verifying personal identification.. A number of new study difficulties have emerged over this period, one of which is the potentially deteriorating influence of biology-related alterations in the human eye, such as those induced by ocular disorders, but also post-mortem degradation processes. The goal of this doctorate dissertation is to assess the harmful impact that these changes may have on iris biometrics systems, as well as to identify what causes mistakes and provide remedies to mitigate such errors.

The use of machine learning to find and categorise patterns across a wide range of related disciplines of study has shown tremendous promise in recent years. The current study aims to compare the performance of Convolutional

Neural Network (CNN) methods and architectures such as Inceptionv3, VGG16, and RasNet50 with data augmentation and transfer learning to traditional machine learning techniques such as Support Vector Machine (SVM), random forest, and analyse their usefulness in Iris recognition in terms of accuracy, precision, recall, and training time, as well as their usefulness in image classification. Using the "Warsaw-BioBase-Post-Mortem-Iris v3.0 and v4.0" dataset used by the Post-mortem Iris Detection System, the models were trained. The dataset is a collection of data generated by Warsaw University of Technology and Medical University of Warsaw in Poland in collaboration and was used to train the models.

1. Introduction

Post-mortem iris recognition has recently gained attention from the biometrics community, starting with a Master's thesis from Boston University [1] and studies on ex vivo pig eyes in 2015 [2]. Since then, some research groups have been hard at work evaluating how this biometrics works with irises of deceased subjects [3-7], and proposing PAD (Presentation Attack Detection) techniques aimed at detecting cadaver iris presentations to the sensor [8,9]. Post-mortem iris recognition is also discussed as a potentially useful method for forensic proceedings in addition to typical forensic biometric characteristics such as fingerprints, if the method could be applied reliably [7]. Despite this attention, which is concluded with many claims that post-mortem iris biometrics, however challenging, may still be possible in favorable conditions, no specific, cadaver-aware methods for improving the recognition reliability have been proposed, apart from the work of Trokielewicz et al. [10], who introduced a data-driven semantic segmentation model for iris localization within images collected from cadaver

eyes, yet without evaluating how the new segmentation algorithm improves the recognition accuracy.

2. Literature Review

2.1 Common beliefs and opinions

A belief that iris recognition is difficult or impossible after a person's death has been hypothesized for a long time in both scientific and industry communities. In 2001, John Daugman, who without doubt can be referred to as 'the father of iris recognition', stated the following in his interview for the BBC: 'soon after death, the pupil dilates considerably, and the cornea becomes cloudy'. While this statement is fairly moderate, others put forward far stronger claims, for instance, Szczepanski et al. write that 'the iris (...) decays only a few minutes after death' [11]. References to post-mortem iris recognition can be also found commercial materials, for instance: (...) the notion of stealing someone's iris after death is scientifically impossible. The iris is a muscle; it completely relaxes after death and results in a fully dilated pupil with no visible iris at all. A dead person simply does not have a usable iris!' [12], or 'after death, a person's iris features will vanish along with pupil's dilation' [13]. However, none of these assertions are backed by any scientific argumentation or experimentation.

2.2. Experimental studies

Due to technical and ethical difficulties in collecting biometric samples from cadavers, only a small number of researchers have studied the post-mortem iris recognition problem using scientific methods. Sansola [14] used IriShield M2120U iris recognition camera together with IriCore matching software in her experiments involving 43 subjects who had their irises photographed at different post-mortem time intervals.

Depending on the post-mortem interval, the method yielded 19-30% of false non-matches and no false matches. She reported a relationship between eye color and post-mortem comparison scores, with blue/gray eyes yielding lower correct match rates (59%) than brown (82%) or green/hazel eyes (88%). Saripalle et al. [15] used ex-vivo eyes of domestic pigs and they came to the conclusion that irises are slowly degrading after being taken out of the body, and lose their biometric capabilities 6 to 8 hours after death (2015).

However, ex-vivo eye degradation is expected to be much faster than the same processes occurring while the eye is still a part of the cadaver. Ross [16] observed a fadeout of the pupillary and limbic boundaries found in post-mortem iris images, as well as corneal opacity, which developed in all of the samples under observation.

Later in [17], these experiments were extended to a larger database, encompassingsamples collected up to 17 days post-mortem. A short-term analysis, concentrating on samples acquired up to 60 hours after death, revealed that the best performing IriCore method can still offer EER as low as 13%, which indicates that iris recognition can still be a reasonable identification tool after such a period of time. Long-term analysis taking into account all samples collected over a period of 17 days, however, shows that the iris deterioration progresses fast over such a long time horizon, and although correct matches can still be expected even after these 17 days, they are sparse and cannot be considered a reliable proof of one's identity post-demise. In this work, we have also offered the first publicly available database of 1330 near-infrared and visible light post-mortem iris images acquired from 17 cadavers [18].

Bolme et al. [19] attempted to track biometric capabilities of face, fingerprint and iris during human decomposition. Twelve subjects were placed in the outdoor conditions to assess how the environment and time affect the biometric performance. Although fingerprints and face are shown to be moderately resilient to decomposition, the irises degraded quickly regardless of the temperature. The authors state that irises typically became useless from the recognition viewpoint only a few days after exposition to outdoor conditions, and if the bodies are kept outside for 14 days the correct verification rate was only 0.6% in their study. The real-life chance of recognizing an iris is estimated by the authors to be less than 0.1%. The most recent paper in this field by Sauerwein et al. [20] showed that irises stay readable for up to 34 days after death, when cadavers were kept in outdoor conditions during winter. The readability was assessed by human experts acquiring the samples and no iris recognition algorithms were used in this study, however it suggests that low temperatures increase the chances to see an iris even in a cadaver left outside for a longer time.

2.3. Conclusions from the literature review

In previous studies' evaluations are usually sufferings from very limited data available to researchers. Until 2020, there was no publicly available database comprising iris images collected from dead subjects after 17days his/her death. Notably, none of these papers offer any kind of method that is aimed for making iris biometrics more robust against post-mortem changes to the human eye.

Therefore, the question of how to get post-mortem iris recognition to work reliably in such scenarios was still open. This research work proposes the first such method.

3. Statement of the Problem

It was determined that post-mortem iris identification was the most difficult challenge to solve in this study. The primary goal in this study is to present a methodology, design, and implementation of an iris identification system in order to achieve high accuracy in identifying human iris by using two distinct approaches to this problem. Both approaches make use of machine learning techniques, with the first using conventional machine learning methods and the second employing deep learning algorithms. Transfer learning algorithms are also used in the context of the deep learning technique.

4. The Motivation

In recent years, iris recognition systems have risen to become one of the most reliable identification methods available, thanks to its many applications in computer vision applications such as security systems and visual surveillance. There are several instances that demonstrate the significance of the iris recognition technology. For example, the battle against crime, the growth in terrorist threats, and the implementation of security measures in airports are all important. The iris is considered appropriate for determining an individual's identification because it has several benefits, including the fact that it is an internal organ of the eye, which means it is well protected, and that it is a visible organ, which means that distant imaging is conceivable. It is believed that the iris is formed in the human during the seventh month of pregnancy prior to birth, and as a result, it is considered a fixed feature throughout human life. Finally, research has demonstrated that even identical twins have different iris patterns, and as a result, it is considered to be superior to other biometric applications in terms of defining an individual's identity. It is the primary goal of this study to develop and build a system that can detect human post-mortem iris patterns in order to utilise them as biometric identification methods in the future. The emphasis will be on developing and implementing two ways for doing iris recognition, as well as comparing the results achieved from these approaches.

5. Research Question

This study is concerned with the investigation of the following research topic.

When it comes to improving the performance of post-mortem iris recognition systems, what is the most successful way, whether it's standard machine learning or deep learning method?

6. Aim

The purpose of this study is to determine the most effective way for post-mortem iris recognition systems.

Image processing, feature extraction, machine learning, deep learning, and transfer learning are all examples of what is available.

7. Objectives

The following are the general objectives of this research:

- Using machine algorithms to accurately identify post-mortem iris.
- Develop post-mortem iris recognition systems based on CNN and transfer learning models such as VGG16, Inception v3, ResNet 50 based on CNN architecture, as well as traditional machine learning supervised classification methods such as Support Vector Machine and Random Forest; and
- To fine-tune the customised CNN model and examine the influence it has on the outcomes achieved.

8. Methodology

The structure of the research approach used in the investigation of post-mortem iris recognition is discussed in depth in this section. A thorough consideration was given to the approach used in the study in order to ensure it was appropriate for the research field under consideration. According to the researcher, the design of the study that was adopted for the aim of this investigation and the

rationale behind that design are described. Predicated descriptions of the data collecting instrument and the techniques utilised to carry out this investigation are provided. A total of two alternative techniques for Post-mortem Iris Detection are tested in this study. Both approaches use conventional machine learning algorithms, with the first using classical machine learning techniques and the second employing a deep learning algorithm. Transfer learning methods are also used in the deep learning methodology.

9. Significance

Along with traditional forensic biometric features such as fingerprints, it is also considered that post-mortem iris recognition might be a potentially effective tool for forensic proceedings in addition to fingerprints. When additional biometric traits are not available to identify a person, iris recognition may be used to determine their identification up to 35 days after death. In such cases, iris recognition can be very useful in forensic investigations.

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